BASIC STEPS IN CONDUCTING SURVEYS

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I. BACKGROUND

The California Energy Commission (Commission) is currently examining its consumer data collection and submission requirements as one phase of an Order Initiating Rulemaking (OIR). Existing regulations require utilities to conduct surveys to acquire consumer structural characteristics data and to submit those data to the Commission. Assertions have been made that surveys can and should be used for additional purposes. However, any changes in the Commission regulations should be based on an understanding of what surveys can do, how well they can do it, and at what cost.

This paper describes the basic steps involved in conducting a survey. It is one of a set of papers prepared for the 10/13/98 workshop of the current OIR proceeding. This workshop will focus on consumer information alternatives. With an understanding of the survey process, participants in this workshop will be better able to evaluate the appropriateness of using surveys as an alternative for collecting the data needed by the Commission.

II. WHEN ARE SURVEYS APPROPRIATE?

Surveys are a means of meeting an information need. Surveying is the act of collecting information about a population of interest. Obviously, when the needed data are already organized in an available database, there is no need to undertake a survey to collect the desired information. However, when this is not the case, then censuses or sample surveys may be appropriate means for gathering the needed data.

A census is a special case of a survey in which information is gathered for every member of the population. A sample survey collects information on a subset of the population with the purpose of estimating population parameters (e.g., averages, proportions, measures of population variability) on variables of interest.

A sample survey that is conducted following scientific methods can often produce results that are accurate enough to meet the information need. These methods include collecting information using standardized procedures and choosing the sample so that each member of the population has a measurable chance of being selected. Following these methods allows the survey results to be generalized to the entire population with confidence.

Because a well-executed sample survey can produce accurate enough results, there are advantages to choosing surveys over censuses. Because sample surveys collect information from only a fraction of the population, they will be less expensive and more timely than censuses. In addition, they can be more accurate than some censuses. With the smaller sampling effort, more resources can be focused on obtaining responses from those less likely to respond. Smaller-scale efforts can also devote relatively more resources to training and supervising personnel, and data management tasks are also less prone to error. In many ways, sample surveys may lead to more accurate and trustworthy results than a census.

III. BASIC STEPS INVOLVED IN CONDUCTING A SURVEY

There are many interrelated activities involved in conducting a survey, and these activities are not necessarily sequential. Some of the more important steps include specifying:

1) survey objectives
2) overall design
3) sample design
4) questionnaire development
5) survey implementation
6) data analysis and report preparation.

Every survey is subject to errors, usually classified as sampling errors and nonsampling errors. Sampling errors occur because estimates of population characteristics are derived from data from only a portion of the population rather than from the entire population. Nonsampling or measurement errors encompass the remaining errors, e.g., errors when respondents provide incorrect answers or the survey fails to obtain an answer at all. Adequate planning in each of the six steps above helps to minimize survey errors and thus to promote accurate, representative results. We will discuss each of the six survey steps in this light.

A. Objectives of the Survey

A well-executed survey requires clearly stated objectives. These objectives determine what population is to be the focus of the study and what data will be collected. The survey sponsor will also need to define terms, specify what resources are available to conduct the survey, and possibly determine analysis methods. How a survey is designed and conducted can be viewed as a maximization problem given these competing factors.

Example. An example of a survey objective comes from the September 1997 PG&E ***Commercial Building Survey Report*** (available on PG&E's web site):

> The goal of this effort was to provide a more current and robust data resource for understanding our [commercial] customers and their energy usage and needs ... This survey collected information about the customers' building structures, business operations, equipment types, fuel choices, and operating schedules. This information, along with billing data and other available customer information, was further analyzed to produce simulated end-use intensities and simulated end-use sales.

B. Overall Design

Surveys can be classified using many criteria. For our purposes, we will focus on surveys requiring self-reported data, and we will classify them by method of contact. The methods usually considered include self-administered mail surveys, telephone interviews, in-person surveys, or some combination of these three approaches. More recently, electronic media have also figured in the overall survey design. For example, the US Bureau of Labor Statistics follows a panel of business establishments in which the respondents supply monthly data via touch-tone telephone entries that are directly connected to the agency's computers.[1]

Each survey method has its strengths and weaknesses.[2] Table 1 lists some of these for in-person, telephone, and mail surveys.

Table 1
Some Strengths of Selected Survey Methods

In-person and Telephone Surveys	Mail Surveys
High response rate with low (unknown) bias from refusals	True answers instead of socially desirable answers
Desired respondent is the same as actual	No interviewer distortion/subversion

[1] ASA, ***How To Collect Survey Data*****,** Section on Survey Research Methods, American Statistical Association, Alexandria, VA, 1995, p.2.
[2] See Don A. Dillman, ***Mail and Telephone Surveys, The Total Design Method,*** John Wiley & Sons, New York, 1978.

respondent	
	Time to gather information for accurate answers
Low item nonresponse	
Timely (telephone surveys)	Less demanding personnel requirements
	Low cost

Referring to the table, in-person and telephone survey results are more likely than mail survey results to reflect the targeted population. This is because in general, in-person and telephone surveys achieve higher response rates and reach the desired respondent more often than mail surveys. In-person and telephone surveys also allow better question flow control such that fewer questions are left unanswered and item nonresponse is low. Finally, telephone surveys are especially useful when timely answers are required.

Mail surveys have their greatest strengths when accurate answers and personnel requirements are important. With mail surveys, respondents are more likely to report true answers rather than the socially desirable answers they might provide to an interviewer. There is no interviewer distortion or subversion with mail surveys. For the highly motivated mail respondent, there is more time to retrieve data and/or consult with knowledgeable people in order to report accurate answers. However, we note that for all three survey types and/or unmotivated respondents, burdensome searching of records or computations that certain questions might require will lead to nonresponse or inaccurate responses. For mail surveys, personnel requirements are less demanding because mail surveys do not involve interviewer hiring and training, and finally, mail surveys are less expensive than in-person or telephone surveys of the same size.

In recent commercial and industrial surveys, utilities have utilized another survey method, onsite audits, to gather data. This method uses trained auditors who not only conduct in-person interviews but also walk through premises noting equipment holdings and building characteristics. Onsite audits are well-suited to situations where complex data are needed but where the customer is unlikely to have knowledge about these data. This will often be the case for commercial and industrial premises where complex heating, cooling, and other systems are present.

The selection of an appropriate survey method involves many considerations. As Dillman explains:[3]

> Although each method has certain strengths and weaknesses, they do not apply equally, or sometimes at all, to every survey situation. Thus, until the attributes of each method are considered in relation to the study topic, the population to be surveyed, and the precise survey objectives, the question of which is best cannot be answered.

At this stage in the survey process, the survey designer should also consider whether data collected in the survey or used in any of the survey steps are confidential. If so, appropriate procedures and measures can be implemented to ensure that confidential data are protected from disclosure.

Example. To illustrate the above, consider recent utility commercial energy use surveys. These surveys utilized onsite audits as the survey method. Of particular concern was the ability to collect complex, detailed data that are often unknown to commercial customers. For example, for some equipment such as air conditioning, the surveys collected type, fuel type, and nameplate information, while in the building characteristics area, the surveys gathered details on features such as R-value of any wall and attic insulation. Telephone or mail surveys do not reliably collect this type of information because respondents do not have a high level of knowledge about these

[3] ***Ibid***, p. 39.

topics. In addition, the onsite survey method satisfied representative sample criteria, though the smaller sample size due to cost constraints meant relatively lower precision. The onsite surveys were expensive, but low cost considerations were outweighed by the value of obtaining high quality data.

C. Sample Design

As mentioned above, a sample survey collects information on a subset of the population with the purpose of estimating (unknown) population characteristics. Because data are only collected from a portion of the population, i.e., the sample, sampling error occurs. Consider that every replication of the survey experiment results in a different sample and therefore in different estimates.[4] Sampling error describes the magnitude of these differences. A survey designer can control sampling error through the sample design and sufficiently large sample size. Thus, a well-designed sample can minimize sampling error and thus maximize the precision of the survey results for given costs.

The development of the sample design includes many steps which we will group together under three headings for the purposes of this discussion. The three steps are: 1) sample frame development, 2) population stratification, and 3) sample size and selection.

1. Sample frame development.

In this step, the units of analysis are defined and a complete listing of the targeted population is compiled. Because the sample, or portion of the population, providing information will be selected from this list, it is important that the list be comprehensive. Otherwise, the results from the survey will not represent the population but will be biased. When complete population lists are not readily available, development of the sample frame can be one of the most time-consuming elements of the entire survey process.

Example. Consider utility appliance saturation surveys. The unit of analysis for these surveys was defined as the 'premise' (or household in the residential sector). A premise is

> ... a building or group of buildings (or a portion of a building) which may be served by one or more accounts but where decisions about expenditures and behavior related to energy use are under the managerial control of a single decision-making unit.[5]

Utility and Commission staff chose this definition in order to understand the energy usage of decision-making customers as it related to building characteristics as well as to tie the analysis to other economic and relevant data. To develop a sampling frame of premises, utilities turned to their billing files, which contained information on all accounts being supplied by the utility. Accounts were aggregated to premises, and the resulting list constituted a very good sample frame with respect to complete population coverage. For the residential sector, a billing file sample frame is highly accurate because of the close correspondence of accounts and dwelling units. In the commercial sector, this correspondence becomes less direct due to multiple accounts per premise.

1a. Surveys without a complete listing of units.

There are some sample designs that do not require a complete listing of every unit in the targeted population ***per se***. For example, multi-stage designs may have initial stages with geographic or other sampling units. However, at the final stage, a complete frame of the targeted units must be created.

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[4] This discussion follows Jelke Bethlehem, "Integrated Control Systems for Survey Processing," p. 372, in ***Survey Measurement and Process Quality***, Lars Lyberg et al. (eds.), John Wiley & Sons, Inc., New York, 1977.

[5] EPRI, ***Sampling Methodologies for the Commercial Sector***, EA-3688, Research Project 1216-4, EPRI, Palo Alto, CA, 1984, p.1-3.

Example. The federal Energy Information Administration's (EIA) commercial building energy surveys use multistage area probability cluster sample designs. For past surveys, Census population information was first used to identify geographic areas of high and low population on the assumption that the population of commercial buildings followed population density. These areas were then sampled and sub-sampled (so the initial sampling units were geographic areas). Eventually, at the last stage, actual commercial premises were sampled. In order to do this latter step, inspectors first canvassed the selected geographic areas to update lists of commercial buildings. These lists then comprised the frames from which the sample of commercial buildings was drawn. EIA has been 'forced' into this approach because it does not have access to utility billing files as a starting point for its sampling frame.

Another sampling method that does not require a complete list is random digit dialing (RDD). As its name implies, RDD uses random numbers to generate telephone numbers for a contact list. Ultimately, however, outside information sources must be available to determine the representativeness of the respondent information. The method may not be applicable when small populations are targeted as the frequency of hits will be low. Also, RDD is becoming more problematic with the proliferation of answering machines, multiple household lines, and cell phones, raising questions about the ability to assign selection probabilities to households and thus about representative sampling.

2. Population stratification.

In this step, the domains of study are identified and the population is grouped into the subgroups of interest. We define domains as those particular subdivisions of the population for which separate estimates are desired. By identifying domains up-front, we can allocate a sufficient number of sample points to those subdivisions to permit estimates of the desired precision.

In past appliance saturation surveys, the grouping of premises into domains of study was straight-forward. Customers were grouped into housing types, commercial building types, and industry groups using Standard Industrial Classification (SIC) code information available on utility billing files. Likewise, geographic domains were created using billing file zip code information. In the future, if similar domains will be of interest, it will be necessary to have SIC and zip code information associated with account and premise billing data.

Example. The number of domains can vary widely among surveys. For example, a commercial building saturation survey conducted in a single climate zone territory might only have 12 domains corresponding to each of the 12 commercial building types used for forecasting and analysis purposes. At the other extreme, a survey of consumption for each four-digit level SIC code present in each of California's counties would require approximately 28,500 domains of study.

3. Sample size and selection.

Now that the objectives of the study have been clarified, the sampling frame developed, and the domains specified, the survey designer can turn to the question of sampling method and sample size. One characteristic of a good survey is that

> ... the sample is scientifically chosen so that each person [sampling unit] in the population has a measurable chance of selection. This way, the results can be reliably projected from the sample to the larger population.[6]

There are many sampling methods. Examples include simple random sampling, probability-proportional-to-size sampling, and cluster sampling. The selection of a method depends on what

[6] ASA, ***What Is a Survey?***, p. 2.

information is available about the targeted population and what resources can be devoted to the survey.

While there are different formulas for sample size depending on the method of sampling and the desired estimator, all formulas require information on the variability of the studied characteristics in the population, the level of precision the survey sponsor desires for the estimates, and how much risk the survey sponsor is willing to take that the sample estimate is 'too far' from the true value. In general, for a given method, the sample size will be larger with more variability in the population, greater desired precision, and less acceptable risk.

Example. The existing data collection regulations require designed saturation survey estimates to be within ± 5% of the true value at the system level with 95% confidence that the survey will achieve this precision (that is, given the sampling method, we desire 95% of all possible samples to produce an estimate within ± 5% of the true value). For load metering profiles, the design should ensure that profiles are accurate to within ± 10% of the monthly sector peak with 90% confidence.

In addition to the above, the actual sample size will reflect budget constraints and expected response rates to the survey. For example, in recent years, utilities have shifted to doing more onsite surveys in the commercial building sector in order to obtain accurate data for the complex variables that have proven to be most important for understanding energy usage. Because onsite surveys are expensive (typically ranging from several hundred dollars to close to $1000 per site depending on the level of detail to be collected), the samples have been smaller than they would have been for corresponding mail or phone surveys. Higher precision and lower risk have been traded-off for more accurate data.

An example of the response rate influence can be drawn from mail residential appliance saturation surveys. These surveys have typically achieved 40-60% response rates in the past, so the ideal sample size as calculated from the statistical formulas will usually be doubled in order to assure a sufficient number of responses for analysis. However, note that by increasing the sample size to adjust for nonresponse, the survey designer has in effect substituted large sample size for response-inducing methods. In other words, the designer has used substitutes for those who do not respond to the survey. Even though the desired number of responses may thereby be achieved, there may still be nonresponse bias problems with the survey results.[7]

D. Questionnaire Development

The questionnaire development step is an extensive phase in conducting a survey. Its goal is to create a survey instrument that both provides accurate information and consistent results. Accurate information means that the answers are true or correct. Accuracy is promoted when question misunderstanding is minimized and when the questionnaire is designed and administered in ways that eliminate normative (i.e., socially desirable) and strategic responses. Consistent results are achieved when the survey instrument is effective in eliciting the same answer in the hypothetical case where the survey is administered to the same person multiple times.

There are three phases in the questionnaire development step. First, survey sponsors and specialists determine which questions to ask and how they will be presented in the survey instrument. Second, the instrument is pilot-tested. Finally, the instrument is revised based on results from the pilot test.

Important activities in the first phase of questionnaire development include determining which questions to ask, how they will be worded, in what order they will be asked, and the format of

[7] Dillman, ***op. cit.***, p.49.

the questionnaire booklet for mail surveys. While the survey sponsor determines the major items on the questionnaire, information from focus groups and other sources such as other questionnaires and relevant literature may also influence the content and format of the questionnaire. If the survey is to serve multiple purposes, the affected groups need to be brought into the questionnaire development process. Furthermore, additional questions may be added to the questionnaire to facilitate transition from one section to another, to provide information for verification and estimation purposes, and to allow survey results to be tied to other economic and relevant data. For example, past utility residential appliance saturation surveys not only asked for square footage information on a household's residence but also asked about number of bathrooms and/or bedrooms (to help verify the square footage responses). They also included questions to capture demographic information.

In this first phase, question wording will also be evaluated. It is important to understand the language and perceptions of the targeted population so that the questionnaire language level is appropriate, people understand what the question is asking, and the answer choices are appropriate. In addition, the question order and format of the questionnaire booklet for mail surveys will be selected to ease respondents' ability to answer and complete the questionnaire.

In the second phase, the survey planner pilot-tests the instrument to determine the ease and accuracy with which respondents complete the survey and also, to determine the ease of administration and scoring of the instrument. The pilot test might include interviews with respondents and administrators to learn about how they processed the questions and to discover where the instrument has weaknesses.

In the third phase, the planner uses results from the second phase pilot test to revise the instrument. Resources permitting, the revised instrument can also be pilot-tested and revised until an appropriate instrument has been developed for large-scale use.

E. Survey Implementation

There are many activities involved in this step. Advance and/or cover letters need to be prepared. Letters and mail questionnaires need to be printed, survey packets assembled, and letters and packets mailed. Computer systems need to be set up to handle data entry and computer-assisted telephone or in-person interviews. For telephone and in-person surveys, interviewers need to be recruited and trained, and interviews need to be scheduled and conducted.

There is also a large monitoring effort that takes place in this step. Information needs to be collected on the progress of contacts, eligibility of respondents, callbacks, reasons for nonresponse, conversion efforts, final data collection efforts, areas of particularly high nonresponse and item nonresponse, and outliers. Interviewers need to be monitored to detect any problems. Based on the ongoing collection of these monitoring data, modifications may be appropriate.

This step includes coding survey responses, entering data into computers, and cleaning the data. Weights will be developed reflecting sample selection probabilities and nonresponse rates so that the survey responses can be generalized to the population.

For consumer structural characteristics surveys, customer-specific energy consumption and other billing data will also be merged to each customer's survey responses in this step. Customers are usually not asked to provide this information themselves as the burdensome searching of records necessary for accurate responses is unlikely to be undertaken. Instead, customers may be asked to sign waivers allowing their energy service providers to release billing information to the survey sponsor. However, the billing file merge is least burdensome when the utility distribution companies (UDCs) and energy service providers (ESPs) sponsor the surveys, because they already have the information, or when the UDCs and ESPs make their

billing files available to the survey sponsor. An added advantage to this last option is that consumption data can be used in earlier survey steps to maximize the sample design.

Finally, data sets (electronic files) and codebooks will be prepared in the survey implementation step.

F. Data Analysis and Report Preparation

In the data analysis step, analysts conduct further data editing to assess the consistency of survey responses and results as well as their accuracy. Analysts will also assess nonresponse bias in this phase of the survey and consider whether to apply various methods for imputing data or making other corrections. However, it is worth noting that no statistical method will fully compensate for missing units and data. Therefore, every effort needs to be made to collect complete information during the planning and implementation phases of the survey or by other means. Finally this step includes documenting all the steps in the survey and presenting results. For the appliance saturation surveys conducted by the utilities in the past, this phase can easily take several months.

Where periodic surveys are a normal method of data collection, the successes and failures of the current effort may be identified for their guidance in subsequent efforts. In the more than 20 years that the major utilities have conducted surveys in California, this learning process has been important.

IV. SUMMARY

In the 10/13/98 OIR workshop on consumer information alternatives, surveys are likely to be suggested as a means of collecting the desired consumer data. In light of the general survey description presented above, staff notes the following major points. First, the process of conducting a well-designed survey is complex. However, major expertise have been developed over the past 20 years by utility and Commission staff in the course of conducting surveys to collect consumer structural characteristics and other data. Second, surveys have appropriate roles and are not a universally preferred approach for all data collection. Third, the linkage of responses with precise utility fuel consumption records can create major coordination challenges. Finally, surveys designed to collect complex data at detailed geographic levels will be expensive.